# Methods for estimating bird populations[1]

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*(With a plate & two diagrams)*

This paper attempts to describe a number of methods for the estimation of bird populations. The kind of method employed will depend on a variety of factors; the purpose for which the estimate is required, the ecology and behaviour of the species concerned, and the degree of accuracy considered necessary.

In the case of an economically important bird pest, causing direct damage to a standing crop it may be sufficient simply to estimate the damage, and assess the reduction in damage resulting from various control measures tested. An example of this kind of situation would be the use of tape-recordings or shots to scare birds away from orchards. The success of the technique can be assessed directly from the decrease in the percentage of damaged fruit, without knowing how many birds are involved.

In situations requiring some estimates either of the actual number of birds involved, or of relative changes in the size of a particular population, a method must be chosen appropriate to the task in hand. Population estimates, in terms of birds/unit area are generally more difficult to achieve than population indices, which allow comparison between different years, seasons, or areas without giving an idea of the actual number of birds involved.

Where a detailed population study is being carried out it is best to employ both estimates and indices. If a number of populations of the same species are examined, and estimates and indices compared then it may become possible to relate the index figures to the estimates so that actual population figures can be derived from the indices, which usually involve less field-work.

## Comparative Indices

1) *Line transects.* These are performed by one or more observers walk-

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ing or driving through the area of study, and counting all individual birds seen. The observer's route should be selected prior to the start of the transect, and should, if possible, be random with respect to variations in the habitat, though this is not always possible if pre-existing footpaths or field borders are followed. When comparing population changes with time over a particular area then the transect, one chosen, should be followed exactly on each subsequent visit. If two different areas are being compared for their relative population densities then transects in the two areas should be equal in length, and an equal length of time should be spent on each.

The length of the transect will depend on the abundance of the bird species being censused. If the area is small then there is no theoretical objection to criss-crossing the same ground, or to counting the same bird twice, provided that this is not done knowingly. A transect of 2-3 miles might be sufficient for counting Bulbuls (*Pycnonotus* spp.) in scrub, whereas a suitable transect for Coursers (*Cursorius* spp.) in the desert might involve a jeep ride of 50 miles.

Line transects are usually used in fairly uniform habitat, or in habitat such as mixed scrub and woodland, where the observer can, on any random route, pass through several patches of each of the constituent vegetational types.

The activity, and hence the visibility, of birds varies with season, weather conditions, and time of day. In order to make successive transects comparable it is important that these factors be taken into consideration. Comparison between different habitats by the transect method is very difficult because birds are unlikely to be equally visible in different types of vegetation. In habitats where the vegetation is dense an auditory transect, made by counting the number of calls heard, rather than the number of birds sighted, may be most useful, but it depends on the species being censused having an unmistakable call. Contact calls and alarm calls are more suitable for this purpose than songs, since singing tends to be seasonal, and usually confined to one sex. The auditory transect is particularly useful in tall woodland where most birds are out of sight in the canopy.

In very open habitats, such as flat desert, or counting sea birds at sea, it is necessary to impose some limit on the distance that birds can be counted from the transect line. At sea a limit of 200 metres is suitable but this has to be estimated by eye, and hence tends to introduce a subjective bias.

An advantage of the transect method is that it is simple to carrry out, and requires no special apparatus. Also, if it is repeated several times over a short period then the resulting figures can be used to calculate a mean and standard deviation, and these give some indication of the reliability of the method.

2) *Tape recordings.* Many birds can readily be attracted to the tape-recorded calls of their own species. A comparative estimate of density can be obtained for these species by using a transect, and playing suitable calls at intervals along the route. Birds attracted to the calls can be counted as they appear, or calls heard in reply can be counted. This method is particularly useful for shy skulking species.

The kind of call employed will depend on the species involved. For most small passerines the song is best, particularly during the breeding season. For birds like Babblers (*Turdoides*), which do not sing, the contact call or the mobbing call can be used. Care must be taken to ensure that the volume at which the call is played remains constant throughout the census, and only observations made at the same time of day, or season can be compared.

3) *Mist netting.* Mist nets (fine nylon nets which trap birds unharmed when they fly into them without seeing them) can be used to assess changes in the abundance of a particular species in a given locality. The number of birds caught depends on many factors; the activity of the birds, the area of nets deployed, the siting of the nets in relation to the vegetation, the amount of time that nets are deployed. Catches made on two days can only be compared if all these factors remained equal.

The effectiveness of mist nets for trapping resident birds declines steadily from the time that they are erected, and if the nets remain in the same sites for several consecutive days local birds learn to avoid them. Ideally there should be sufficient nets available to be able to allow catching 20 or so of the required species within a few hours. Different sites vary widely in the numbers of birds trapped, without any relation to the density of the population, and for this reason it is only permissible to compare catches when nets have been set in exactly the same sites.

This method is probably highly inaccurate, but it can be used in conjunction with population estimates by "capture-recapture" methods. It cannot be used to compare population densities in different habitats, since the structure of the habitat is bound to affect the ease with which birds are trapped. Young birds seem to be more susceptible to trapping with mist nets than older birds, and estimates of populations containing many young birds cannot, therefore, be compared with older populations.

4) *Random nest searching.* An index of the year to year fluctuations in the size of breeding populations of certain species in a particular area can be obtained from the number of nests found annually by random searching, provided that the same amount of time and effort is expended on each year. This makes no allowances for increases in the efficiency of the searcher, and is best suited to species such as Larks and Partridges, where the nest is usually located by flushing the mother bird off the eggs after a systematic beat.

## Population estimates

1) **Estimation of breeding populations.** These will be treated under four headings, depending on the kind of social structure involved. It has to be borne in mind that the breeding population in any one season is usually substantially smaller than the total population size. In some species breeding is deferred until they are several years old, and in other species birds potentially old enough to breed may be inhibited by social factors. In the Jungle Babbler (*T. striatus*) only about 30 per cent of the population breeds in one year.

At the same time establishing the size of the breeding population may be important in some cases because it relates directly to the possible rate of increase of the total population.

a) *Colonial nesters.* Birds which breed in large colonies tend to occupy the same nesting area every year, and such colonies are usually well known locally. Storks, herons, cormorants, pelicans, vultures, and flamingos all come into this category. During the non-breeding season birds from a single colony may spread out over thousands of square miles, and because of this it is very difficult to assess the area which is served by a particular colony or to derive an idea of birds' density in terms of pairs/unit area.

Counting nests in a large colony is subject to a number of potential errors. Some birds may make more than one nest if their first effort is robbed by a predator. In some cases previous years' nests persist, and in others nests may be built so close together that it is impossible to tell the boundaries of individual structures. Uncertainty is increased by the fact that in mixed colonies, such as a heronry, several different species may be the owners of such adjacent nests.

The timing of the count is important. If it is too early then some pairs may not have begun to nest, if it is too late in the season then many will have abandoned their nests due to predation or accidents to the eggs. Ideally several counts should be made at different stages in the season. In tree nesting colonies each tree can be tagged with a label stating the number of nests it carries, or the trees can be mapped, and the number of nests in each entered on the map. The total breeding population can then be calculated by summing the maximum counts for each tree.

In a few cases, such as flamingos, or sea-birds nesting on open beaches, it may be possible to count occupied nests from aerial photographs. This is only useful when the colony is known to comprise only a single species, because the identification of species from aerial photographs is probably not possible. For tree nesting birds, such as storks and vultures, this method is not appropriate because nests in the tops of the trees are likely to obscure those lower down.

Photography can also be useful in counting colonies of cliff-nesting species, such as Griffon Vultures (*Gyps fulvus*), and bank nesters, such as Sand Martins (*Riparia riparia*), and Bank Mynas (*Acridotheres ginginianus*). Once the colony has been photographed a blow-up can be used by the observer to tick off nest holes or nests which can be seen to be in use. At old colonies of Bank Mynas, for instance, some holes may not be in use, while others may be occupied by sparrows. A few hours spent observing the colony, and ticking off those holes in use, should be sufficient to estimate the population at that time, but counts should be repeated at intervals throughout the breeding season to allow for early and late nesters.

Weaver colonies are more difficult to count than those of hole-nesters. The nests are quite conspicuous but not all of those built are used. In the case of the Baya (*Ploceus philippinus*) nests are usually suspended in palms or other trees and can be scored for occupation by observing them from a distance. Colonies of Blackthroated Weavers (*P. benghalensis*) in tall grass, or Streaked Weavers (*P. manyar*) in reed beds, are more difficult to watch, and in these cases it is necessary to examine each nest in order to ascertain whether it is occupied.

Small passerine birds, which have a relatively short breeding cycle, may nest several times in the course of a year, and only a proportion of the population may be breeding at any one time. If this is so it may be impossible to get an accurate idea of the size of the breeding population from counting nests at any time during the season. Colonial nesters, however, tend to have their nesting fairly well synchronised. In cases where strongly asynchronous nesting is suspected it may be that assessment of breeding populations gives no real indication of the size of the total population, and the method is then useful only for comparative purposes.

b) *Semi-colonial nesters.* These are species which do not exhibit much overt territorial behaviour, and tend to nest in the general vicinity of others of their own species, but which may on some occasions nest alone. Colonies are not necessarily in the same place from year to year, and are often rather spread out. In some cases the aggregation of nests may be due to the clustering of suitable nest sites, rather than any positive gregariousness on the part of the birds.

Birds in this category include Munias (*Lonchura* spp.), Parakeets (*Psittacula* spp.), and Bee-eaters (*Merops* spp.). The last two of these probably aggregate due to the proximity of suitable nest sites. A big old tree with a number of holes may accommodate several pairs of Parakeets, and sandy bank in otherwise flat country may concentrate the nests of Bee-eaters.

Methods for assessing the size of colonies are the same as for colonial species, but the amount of work required to ensure that all colo-

nies are located is much greater. Watching for concentrations of birds, and searching suitable sites, should be sufficient in open country, but the area that can be covered diminishes rapidly in scrub and woodland.
c) *Territorial species.* This category includes most species of passerine birds, as well as many birds of prey, game birds, waders, pigeons, non-parasitic cuckoos, owls, kingfishers, and woodpeckers. A number of methods for assessing breeding populations of territorial species by mapping sightings of individual birds, and particularly of singing males, have been devised for use in temperature regions. The 'Common Bird Census' method used for its national survey by the British Trust for Ornithology, will be described, and its drawbacks in the Indian situation discussed.

Finding nests for territorial species is usually impractical for a population of more than about 20 pairs. Instead it is easier to map the territorial system of the population, and this has the advantage that, while nesting may be sporadic, territories should remain fairly constant throughout the breeding season.

The British Trust for Ornithology method (hereafter known as the BTO method) is based on surveys carried out at weekly intervals throughout the season by observers on foot. A study area of about 300 acres of farmland, or 100 acres of woodland is chosen, and a base map of the area at the scale of 25" to the mile prepared, and duplicated.

If the study area is relatively featureless it may be necessary to erect marker posts or paint numbers on the trees in order that the observer can locate himself accurately at any time.

A separate map is used each time that the study area is visited, and this is carried on a clip-board so that observations can be drawn on it easily. The observer follows a route designed to bring him to within about 50 metres of every part of the study area, and each bird sighted in the course of this walk is plotted on the map, using a code of different letters to denote different species, and symbols to denote whether singing or not.

Fig. 1 shows a typical visit map as it appears at the end of one day's visit. Sightings enclosed by circles denote birds seen in song, dots denote individuals not singing, and an arrow connecting two points indicates that the individuals concerned was seen to move from one spot to the other in the BTO census all species are recorded, but the same method could be applied to a few, or only a single species.

A minimum of about 10 visits are made during the season, for each of which a separate map is used. At the end of the season an individual map is prepared for each species by plotting the points for that species from each daily map in turn. Each point is numbered corresponding to the number of the visit, day 1, day 2, etc. An example of the resulting species map is shown in fig. 2.

Fig. 2 depicts a fairly idealised example, and it can be seen that points tend to fall into 6 clearly defined groups, which presumably center on pair territories, with a few scattered observations outside these which can be ignored. This map, therefore, suggests a population of 6 pairs of this species.

The BTO method has been in use in Britain for more than 10 years and its drawbacks are fairly well known. Species which are best censused by this method are those having a short breeding season during which they sing a lot. Birds which like to perch prominently are particularly suitable.

Care should be taken to distinguish unmated males. These usually appear prominently at the beginning of the season, and then later disappear. In some cases they may continue singing long after the other birds have given up.

Birds which present particular difficulties are semi-colonial species, polygamous species, species living in dense vegetation, and species like larks which sing high above the ground, making mapping very difficult. A good practice with singing larks is to watch them until they return to the ground, and then mark that spot.

Species which might be censused by this method in lowland India include those which perch and sing in obvious places, such as the Pied Bushchat (*Saxicola caprata*), Shrikes (*Lanius* spp.), King Crows (*Dicrurus adsimilis*), Rollers (*Coracias benghalensis*), Flycatchers (*Muscicapa* spp.), Robins (*Saxicoloides fulicata*), Magpie Robin (*Copsychus saularis*), and Purple Sunbird (*Nectarinia asiatica*).

Because song is much less important for tropical birds than for their temperate counterparts this method has usually been thought inapplicable in tropical situations, but with some modification it should prove useful. Certain species tend to sing a lot at particular times of day, and particular season, and this should be taken into account. Robins, for instance, sing most vigorously before sunrise, while Wren-Warblers (*Prinia*) sing particularly after rain.

A lot depends on the density of the population being censused. If birds are very dense, then it becomes impossible to distinguish the boundaries of individual territories. If birds are fairly spread out, however, it may be possible to map the territories even without observing song, particularly if the birds are attached to a few look-out posts, as is usually the case with shrikes.

In a few cases this method can be used to assess wintering populations, where these defend territories. This applies to the Black Redstart (*Phoenicurus ochruros*), and the Lesser Whitethroat (*Sylvia curruca*), although it must be borne in mind that in this case the territories are individual, not pair territories.

Two factors may tend to upset population estimates based on the

BTO method; if there is an unequal sex ratio then an assessment based on singing birds (males) may not give an accurate idea of the number of pairs. For some species there is evidence that males outnumber females, and in this case unmated males may inflate the estimate. Also, if there is a large non-breeding, non territory-holding population this may tend to confuse the estimate by obscuring the pattern of territories.

A technique which can be employed in conjunction with a BTO type mapping survey is colour marking with coloured plastic leg-rings, so that birds can be identified individually. This can be used as a check over a small part of the study area to assess the efficiency of straightforward mapping.

Plastic rings are commercially available in England in different sizes and colours, but can also be manufactured out of sheets of coloured plastic, cut into suitable lengths and moulded. Birds should be marked with combinations of different colours. If 10 colours are available this gives a possibility of 100 combinations using two rings in either order (i.e. Red/Green and Green/Red). It is usually advisable to use the same combination on both legs so that the bird can be identified even if only one leg is visible.

This method is best for species which can be readily trapped, such as Robins, Tailor Birds (*Orthotomus sutorius*), or Yellow-eyed Babblers (*Chrysomma sinensis*). Once a suitable number of birds have been marked (about 30-40 at least) then mapping can be carried out as for the BTO census, with the advantage that the territory of a particular individual can be distinguished by known sightings inserted of inferred from the grouping of points.

An advantage of the colour marking method is that it enables non-breeding wanderers to be readily detected. A population containing many of these would result in some colour ringed birds being seen repeatedly (the territory holders), and others never, or seldom being seen again after their marking (the wanderers). From the proportion of those judged to be territory holders to those judged to be wanderers it may be possible to assess the actual size of the non-breeding population, but a snag here is that the trapping method may not be equally effective for both categories. Territory holders are usually less susceptible to catching in mist nets, for instance, than non-territory holders.

The main drawbacks of the colour marking method is that it is very time consuming, and it requires an observer with acute colour vision. It provides much more information about the structure of the population, the size of territories, and the movements of individuals than any other method, however, and is probably the best if a really detailed study of the species' biology is required.

d) *Group territorial species.* These are species in which territories are occupied not by pairs, but by groups of birds, ranging in size from 3-30.

These are fairly easily censused because most of these species are strictly resident throughout the year, and also defend their territories year-round. Because of the variation in the size of flocks these can often be identified individually over small areas by the number of birds that they contain, alternatively some members can be colour marked. The flocks can then be mapped in the same way that their territories are mapped. The winter season is probably the most suitable for counting of flocks, because during the breeding season these have a tendency to fragment during the day. At this season flocks are best counted in the evening when they always join up before flying to roost together.

2) **Sampling methods.** These methods are based on the assessment of the total population by capturing and marking a sample, releasing it, and then taking a second sample in order to find the proportion of marked to unmarked birds. This technique is known 'capture-recapture', or Lincoln Index.

Birds can be marked either with plastic rings, aluminium rings, or with painted or dyed marks on the plumage, or even by clipping the toes. The only limiting criterion for the marking is that it should endure the duration of the study, and that it should not impair the normal activities of the bird.

Once a sample has been marked, and a second sample taken, the total population is calculated from the formula

$$P = S_1 \times S_2/M$$

where P = total population

$S_1$ = first sample marked and released

$S_2$ = second sample captured

M = number of marked individuals captured in the second sample

Hence if 30 birds are captured and marked in the first sample ($S_1$) and 40 captured in $S_2$, of which 20 are marked, then the total population is estimated by

$$P = 30 \times 40/20$$
$$= 60$$

Theoretically there are several conditions which must apply for this calculation to give an accurate approximation. Both samples should be taken from the population entirely at random (i.e. there should be an equal chance of any individual in the population being captured). The first sample should mix completely with the population after being released, and before the second sample is taken. There should be no immigration into, or emigration from, the population between the two samples.

In practice birds do not usually satisfy any of these requirements. Except in isolated cases, such as land birds on an island, or water-birds in a marsh surrounded by arid country, all bird populations are subject

to continual immigration and emigration at the periphery. Even birds which do not hold territory tend to have a preferred range, and this prevents the population from mixing randomly, and in any case there is no trapping method available that can give an entirely random sample of an entire population.

If this method is to be used, then probably the best trapping technique is to use mist nets, but these should be shifted around in such a way as to ensure even coverage of the entire area, both for the first, and the second samples. Baited wire traps cannot be used for this type of calculation as there are always some individuals which repeatedly enter the traps, while others are trap-shy, and never get caught.

This method may be useful when assessing the size of dense roosting flocks, or the population of skulking species inhabiting dense vegetation. It is unlikely to yield an answer better than 50 per cent accurate.

Successive samples can be treated with more elaborate mathematical

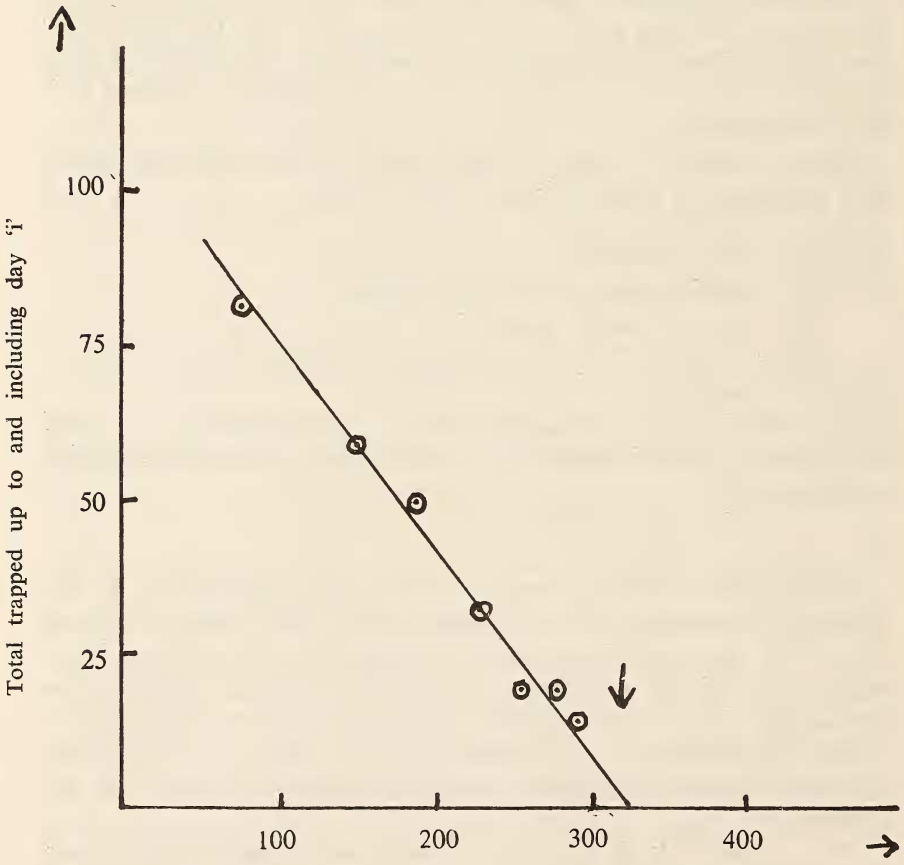


Fig. 1

procedures to yield better estimates but the drawbacks to the method remain the same. These results can also be used in a comparatively simple way, if each successive sample is marked, to yield a population estimate. This is done by plotting the number of unringed birds trapped on any one day against the running total of all birds marked, up to and including that day, on a graph. A sample graph is shown (diagram 1). The x axis shows the total number ringed up to and including day 'i', and the y axis shows the number of unringed birds trapped and ringed on day 'i'. By plotting 3 or more points a line of best fit can be drawn, and extrapolated to meet the x axis. This point (at which no more unringed birds could be caught) gives the total population. This method uses the same assumptions as the capture-recapture method but is easier to calculate for a number of recaptures.

A capture-recapture (Lincoln Index) can also be made using only one day's trapping if the birds are marked in a conspicuous manner. If this is done then, instead of a second trapping, the population can be counted visually for marked and unmarked birds. The resulting calculation is the same as for the usual capture-recapture method, except that in this case $S_2$ is the number of birds observed on the visual survey, and M is the number of those observed which are marked. A sample calculation, therefore, would be; number of birds captured and marked ($S_1$) = 50, number seen on a four hour visit to the area the following day ($S_2$) = 60, of which 15 were marked (M).

Population estimate (P) = $50 \times 60/15 = 200$

3) **Roost counting.** Many species of birds, outside the breeding season, roost in large flocks during the night, scattering to feed during the day, and flighting in to roost about sunset. The size of these roosts can sometimes be estimated by a team of observers counting birds as they arrive at the roost. Most species fly in to the roost in flocks of up to 100 birds and these can be fairly accurately estimated with practice, or in some cases actually counted. At least 4 observers are generally necessary, stationed around the roost, and the sectors covered by each must be clearly defined in order to avoid double counting.

Some water-birds, such as egrets, tend to fly to roost following the line of waterways, and these can be counted by observers sited on these flight lines. Other species which roost communally, and which might be estimated by this method are parakeets, starlings (*Sturnus* spp.), mynas (*Acridotheres* spp.), and crows (*Corvus*).

Roosts can be located by one or more observers moving around by car, and taking compass bearings on the direction taken by flocks flying purposefully just before sunset. Arrows indicating these flight lines can be plotted on a suitable map of the district, and the area at the convergence of the arrows searched on foot to pinpoint the roost. A typical roost-line map is shown (diagram 2).

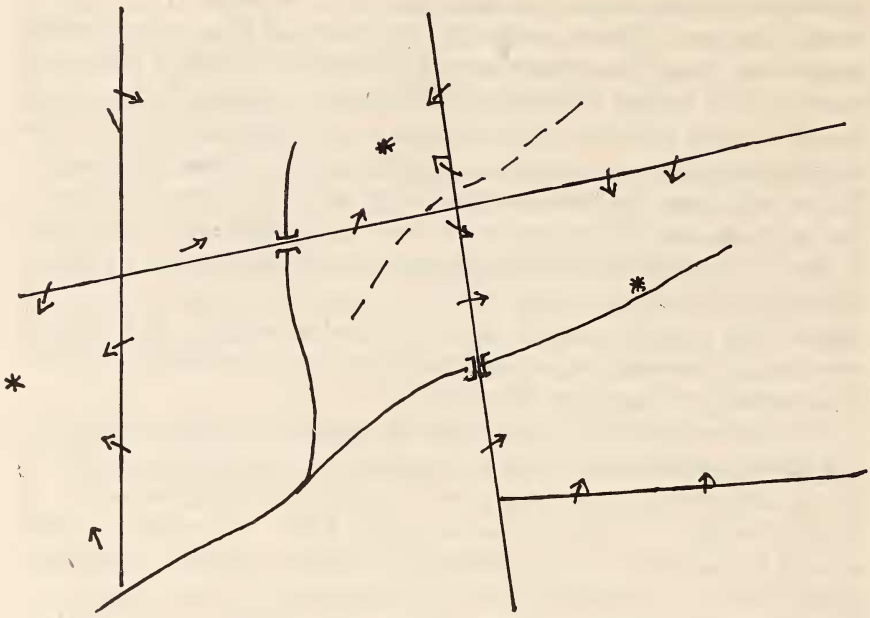

Fig. 2

←—Direction of flocks. * Position of roosts. – – – – Boundary between feeding areas of 2 roosts.

Only roosts of moderate size (about 100-10,000) can be counted in this way. Larger roosts are more difficult because individual flocks flying in tend to be too large to estimate accurately.

A few species which form much smaller roosts might be censused in this way. In particular peafowl, which roost high up in tall trees might be susceptible to this method. On a moonlight night the birds are quite conspicuous against the sky, and can be easily counted. In areas where tall trees are only found in patches roosts can be located during the day by searching the ground under each group of trees for peafowl droppings, which are readily recognisable.

Very large roosts of small birds such as wagtails (*Motacilla* spp.) or swallows (*Hirundo*), which tend to fly in to the roost in ones and twos, cannot be counted satisfactorily. In this instance an estimate can be obtained by catching birds with mist nets and using the capture-recapture techniques. It has been shown for some species, however, that individual birds tend to return to the same position in the roost every night. If this is true then a capture-recapture estimate will be badly biased.

Roosting is not only a nocturnal phenomenon, gulls and shore birds often form resting flocks at high tide, and these can be counted either

while flighting in or while leaving. Ducks and geese tend to feed at night, and form roosting flocks during the day on open water, which can be counted provided that the stretch of water is not too large. Those ducks which feed mainly on open water such as *Aythya* spp. are particularly easy to count. Dabbling ducks (*Anas* spp.) are more difficult because they tend to prefer marshes and reed beds to open water.

In Britain all major open waters are counted monthly by teams of volunteers, and when coverage is complete this can yield a valuable estimate of the water bird population. The important thing is that all counts should be made simultaneously because ducks are extremely mobile, and counts made at different localities on different days would almost certainly lead to double counting.

## Conclusions

Every species of bird, every different habitat requires a technique specially adapted to it. The methods described above are not exhaustive, but provide some indication of the approaches available.

A great deal of work in Britain is being carried out with a view to providing population indices of common birds, and the BTO Common Bird Census is the main outcome of this. Interest mainly centres around the idea that bird populations may provide a sensitive indicator of pollution in terrestrial ecosystems, in the same way that fish can be used as an indicator of river pollution.

Though the kind of amateur participation which can be enlisted in Britain is not available in India it seems likely that a small professional team could provide the same kind of information over limited but representative areas. This kind of work could help to assess the impact of new agricultural techniques, particularly the massive application of fertilisers and pesticides, on bird populations in rural areas. This in turn could furnish evidence, and "early warning" about potentially disastrous changes in the ecosystem.